National Aeronautics and Space Administration

ARSET

Applied Remote Sensing Training

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Exercise with Radar Images

July 14, 2016

Objective

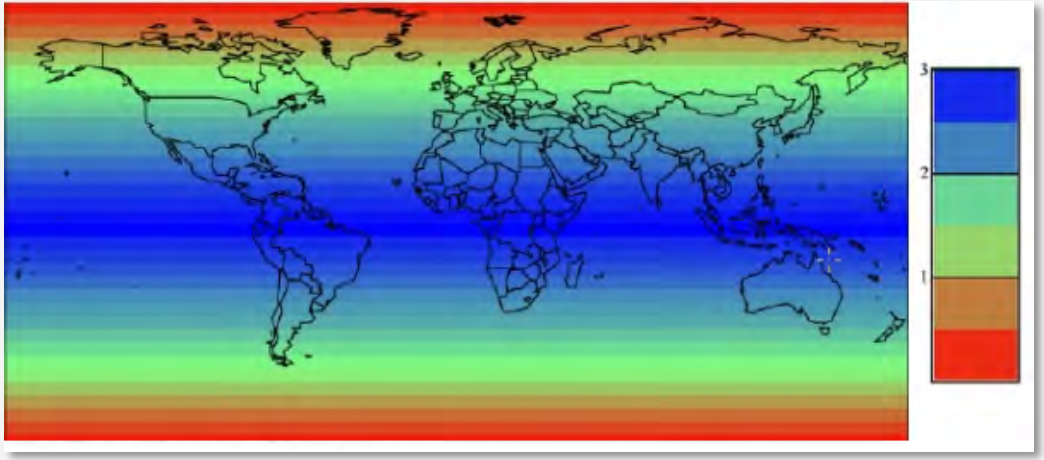
The objective of this exercise is to provide general instructions on how to work with radar data from the Sentinel-1 satellite using the Sentinel-1 Toolbox.

Characteristics of Radar Images from Different Satellites

Sensor Name	RADARSAT-2	Sentinel-1A	RISAT-1
Agency	Canadian Space Program (CSP)	European Space Agency (ESA)	Indian Space Research Organization (ISRO)
Instrument	C-band SAR (5.4 GHz)	C-band SAR (5.4 GHz)	C-band SAR (5.35 GHz)
Incidence Angle	Side-looking, 15-45° off-nadir	Side-looking, 15-45° off-nadir	36.85 deg.
Polarization	HH, HV, VV and VH	(VV and VH) or (HH and HV)	HH an HV
Sensor Height at Equator	798 km	693 km	542 km
Orbit	Sun Synchronous (dusk/dawn)	Sun Synchronous (dusk/dawn)	Sun Synchronous (dusk/dawn)
Revisit time (Orbit Repeat cycle)	24 days	12days	25 days
Resolution	100 m	5 m X 20 m	~25 meters
Swath Width	500 km (ScanSAR mode)	250 km (IWS mode)	115 km (MRS)
Mean local time	6:00 AM Descending	6:00 AM Descending	6:00 AM
Launch	Dec 14th, 2007	April 3rd, 2014	April 26th, 2012
Planned Lifetime	7 years minimum	7 years	5 years

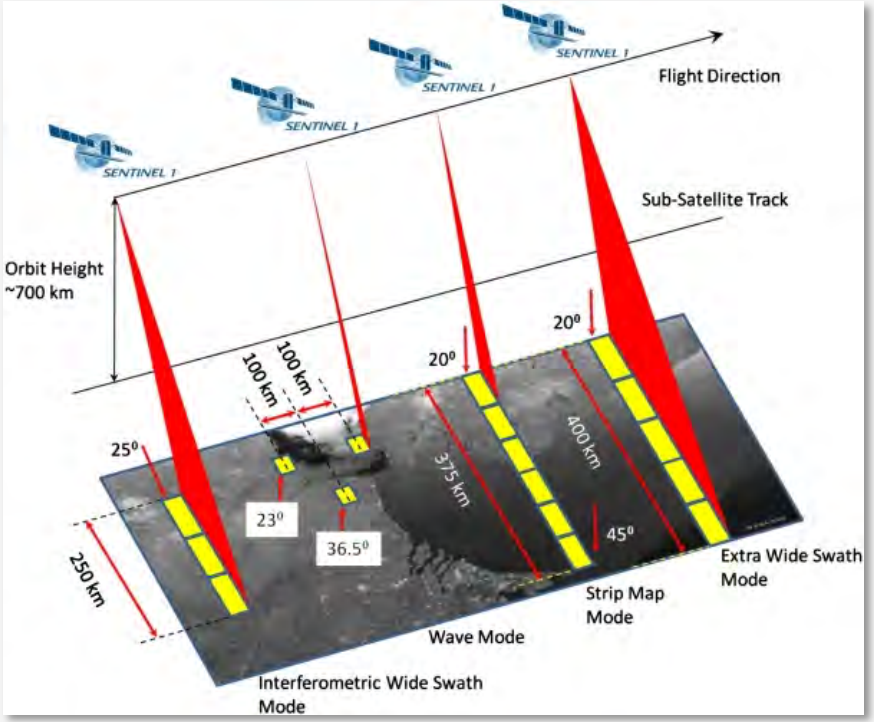
Sentinel-1 Coverage

- Sentinel-1
  - Two satellites: A & B
  - Each satellite has global coverage every 12 days
  - Global coverage of 6 days over the equator when using data from both satellites



Sentinel-1: Modes of Aquisition

1. Extra Wide Swath – for monitoring oceans and coasts
2. Strip Mode – by special order only and intended for special needs
3. Wave Mode – routine collection for the ocean
4. Interferometric Wide Swath – routine collection for land



How to Access Sentinel-1 Images

- Alaska SAR Facility
  - http://www.asf.alaska.edu/sentinel/
- European Space Agency Portal
  - http://sentinel.esa.int/web/sentinel-data-access/access-to-sentinel-data/

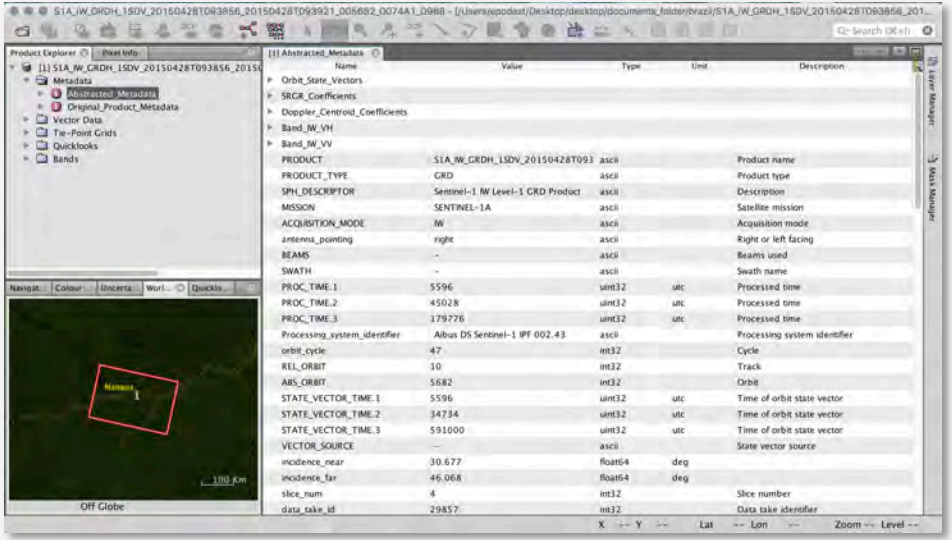
Sentinel-1 Toolbox

- An open source software developed by ESA for processing and analyzing radar images from different satellites
- Includes the following tools
  - Calibration
  - Speckle noise
  - Terrain correction
  - Mosaic production
  - Polarimetry
  - Interferometry
  - Classification

Example: Preprocessing and Analysis

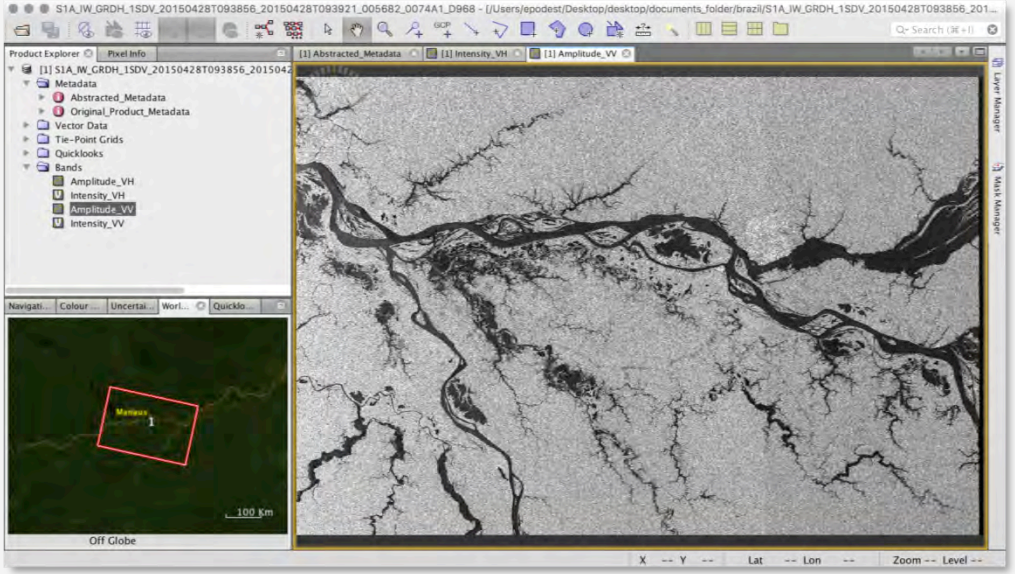
Data Preparation

1. Under “File” and “Open Product” open the Sentinel-1 image (in .zip format)
2. The “Product Explorer” window on the left contains information relevant to the image. It includes:
   – Metadata: different parameters related to the orbit and data
   – Tie Point Grids: interpolation of lat/ lon, incidence angle, etc.
   – Bands: the bands within the file



Data Preparation

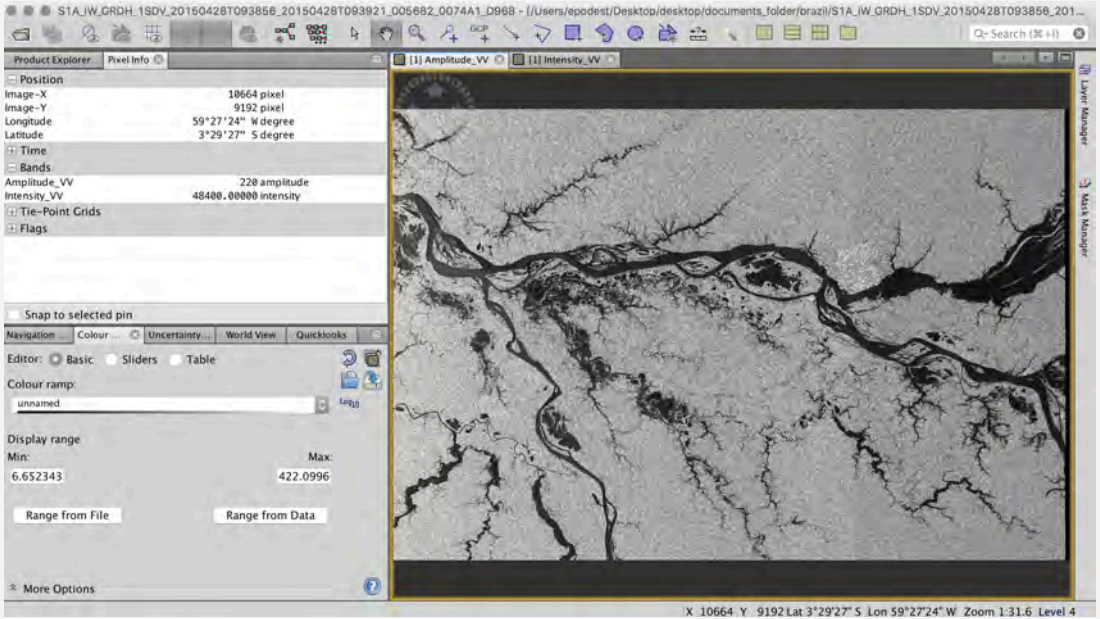
- There are two bands for each polarization
  - intensity and phase
- The intensity image is amplitude squared
- In the lower left you can see in WorldView the coverage of the image selected
- The image is inverted because it is oriented in the same way it is acquired



Data Preparation

Pixel Information

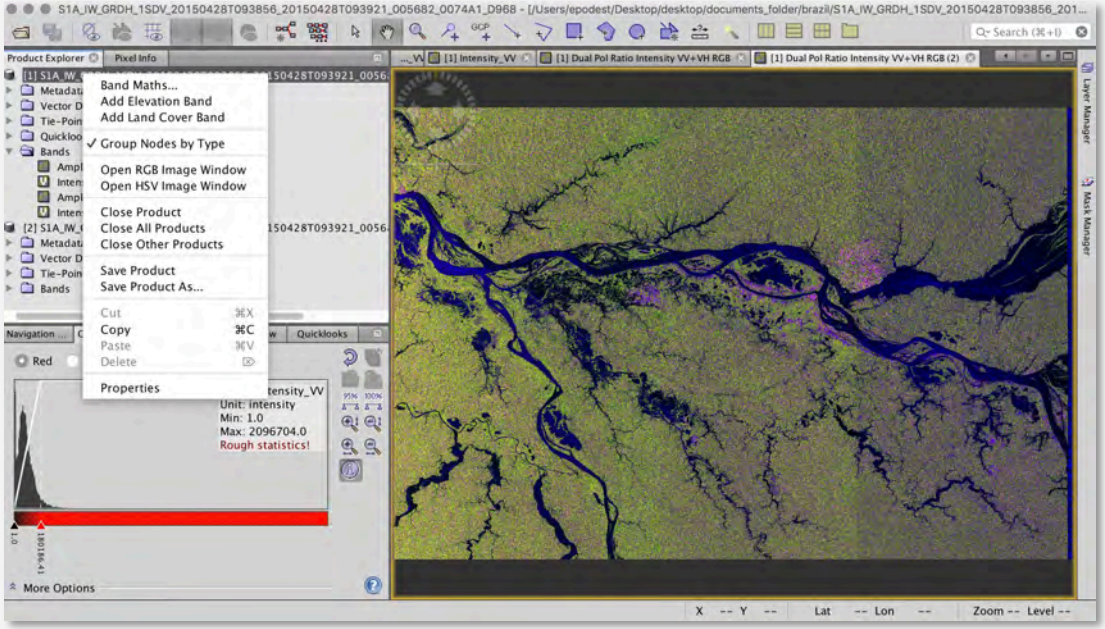
In the upper left window select “Pixel Info” to see the value and the lat/lon of each pixel in the image opened



Data Preparation

RGB Image

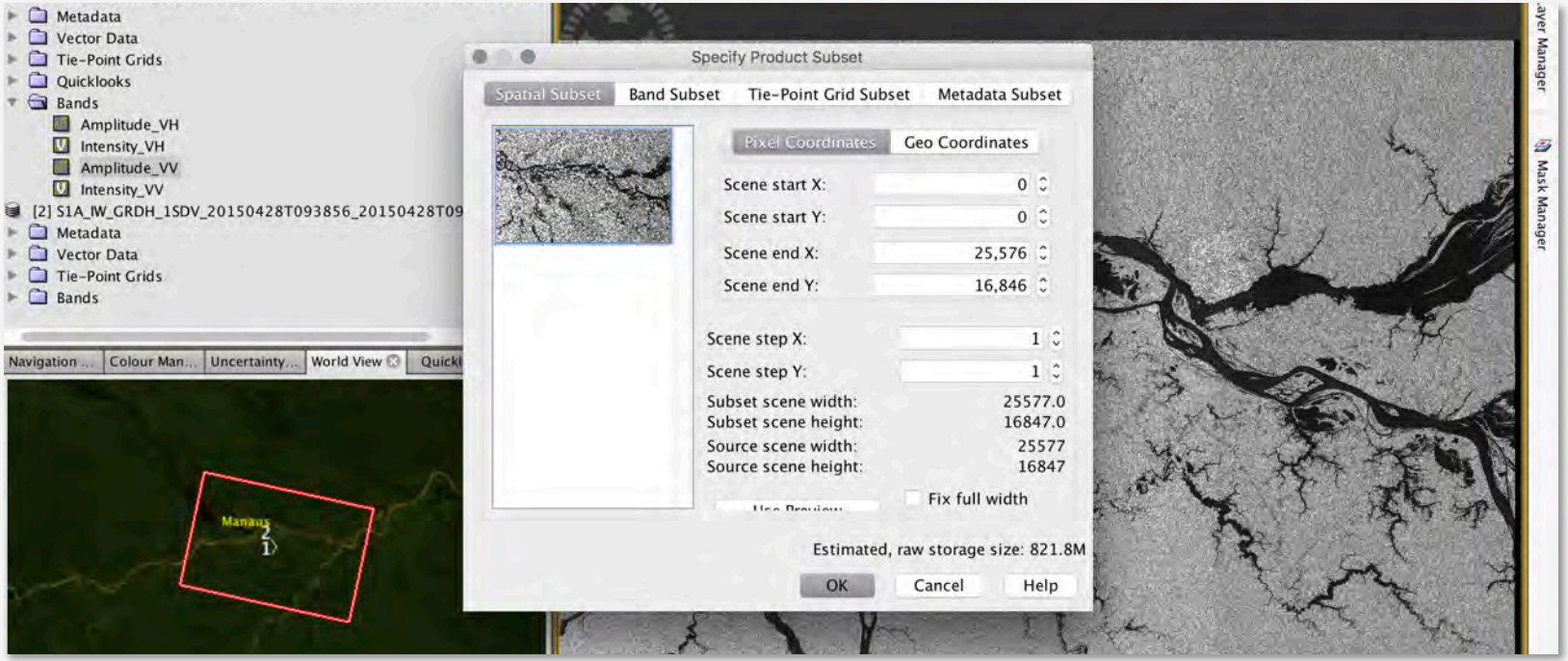
In the upper left window select the filename of the Sentinel-1 dataset. Afterwards select “Open RGB Image Window”



Data Preparation

Defining a Subset

Select “Raster” and then “Subset”



Preprocessing: Geometric and Radiometric Calibration

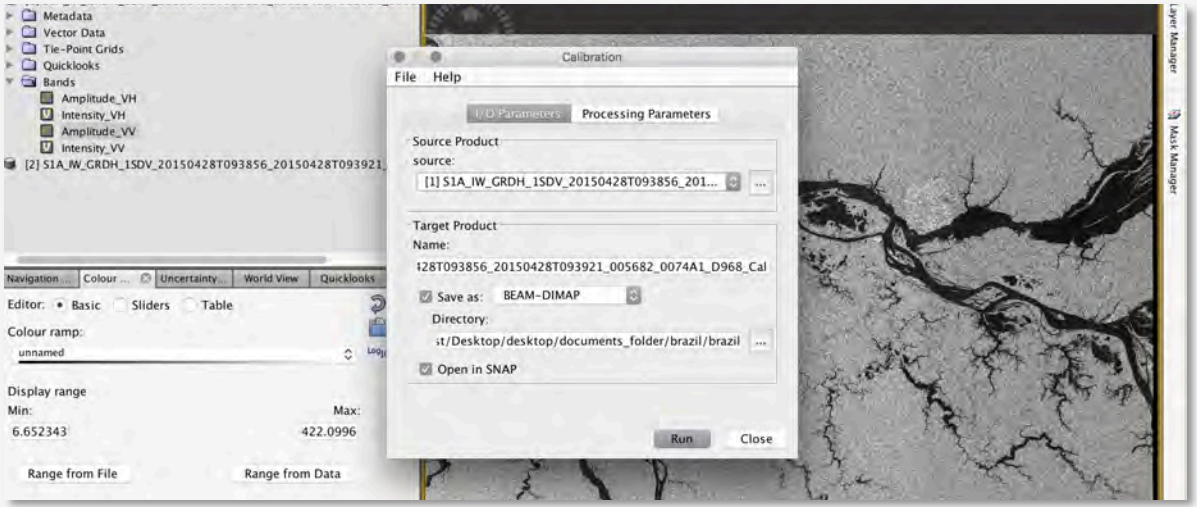
- The objective in performing a calibration is to create an image where the value of each pixel is directly related with the backscatter of the surface.
- This process is essential for analyzing the images in a quantitative way. It is also important for comparing images from different sensors, modalities, processors or acquired at different times.

Example: Preprocessing – Radiometric Calibration

Select “Radar- Radiometric- Calibrate”

The main radiometric distortions are due to:

1. Signal lsos as it propagates
2. Non-uniform antenna pattern
3. Difference in gain
4. Saturation
5. Speckle



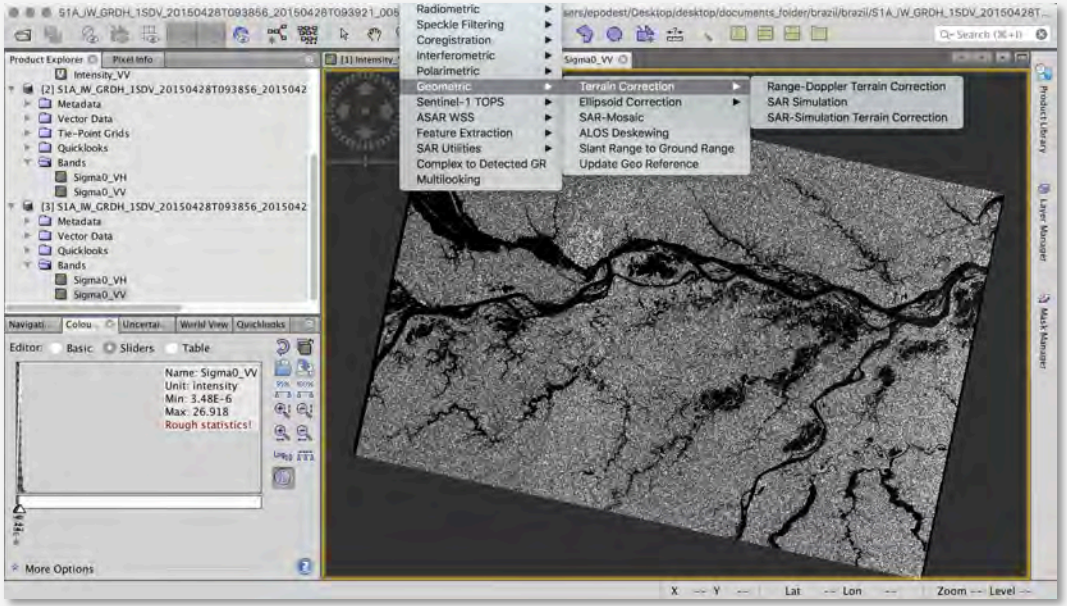
Example: Preprocessing – Geometric Calibration

Select “Radar- Geometric- Terrain Correction- Range Dopler”

The main geometric distortions are due to:

1. Slant Range
2. Layover
3. Shadow
4. Foreshortening

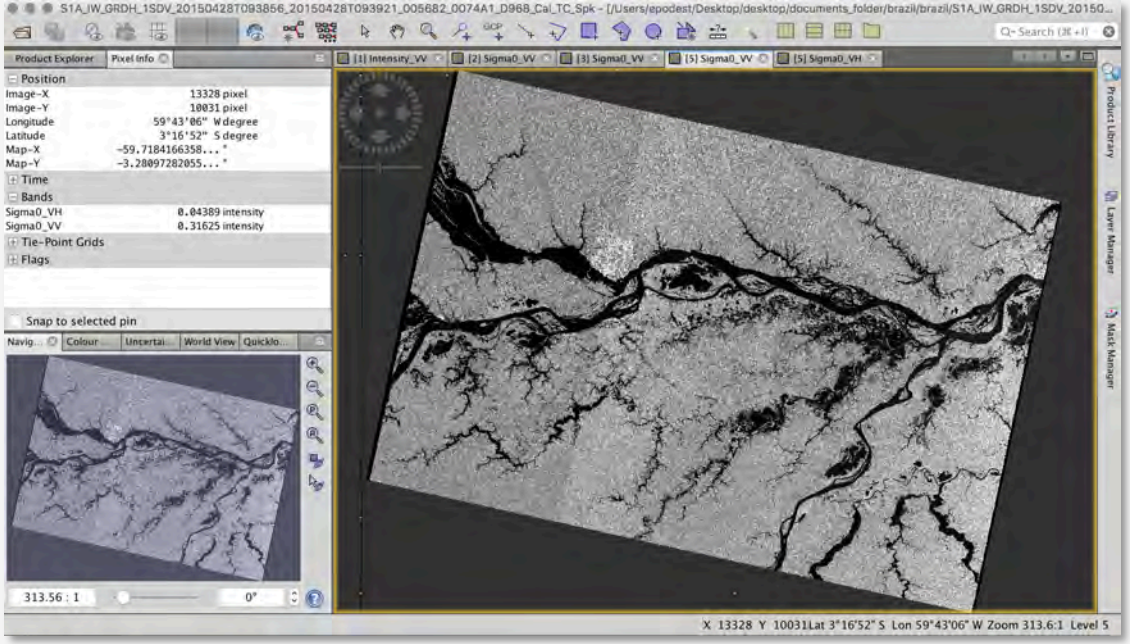
- The algorithm uses a DEM to make corrections
- The corrected image is in its correct orientation



Example: Preprocessing – Speckle Filter

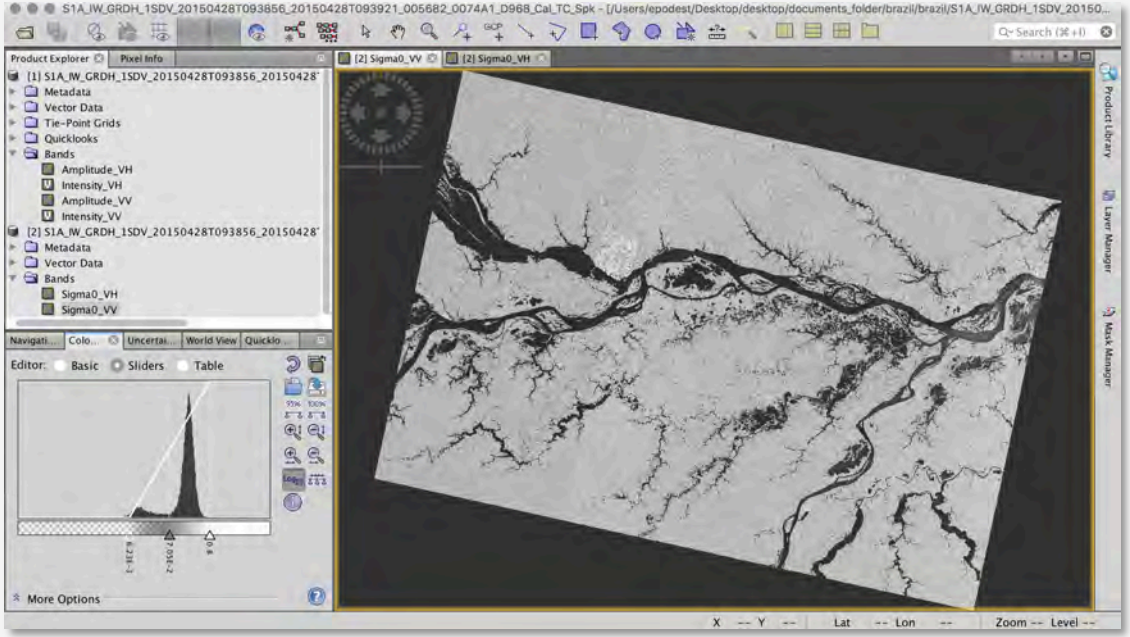
Seleccionar “Radar- Speckle Filtering- Single Product”

- Speckle is part of radar images and makes interpretation difficult because the “salt and pepper” effect corrupts information about the surface
- There are many techniques to extract information from radar images that have lots of speckle
  - In this case, we will use the Lee filter



Example: Processing – Classifying Water and Land

1. Analyze the image histogram in the lower left window
2. Identify the two peaks – the lower one represents water and the higher one represents everything else
3. Select the value that separates water from everything else. In this case it is 2.2×10^{-2}

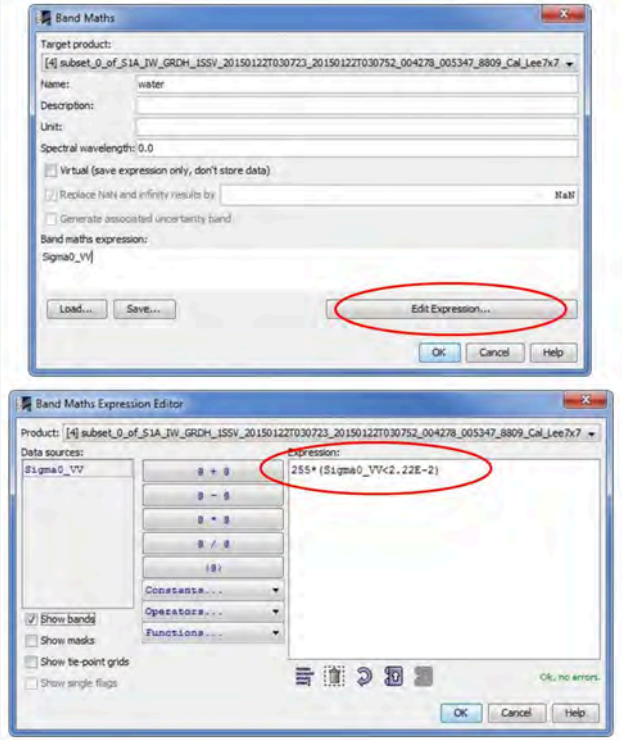


Example: Processing – Classifying Water and Land

Select “Raster- Band- Math”

1. To segment the image, apply band math
2. Edit the expression so that it indicates:

   255*(Sigma0_VV<2.22E-2)
3. The result will be an image where water will have a value of 255. Call this new image “water”



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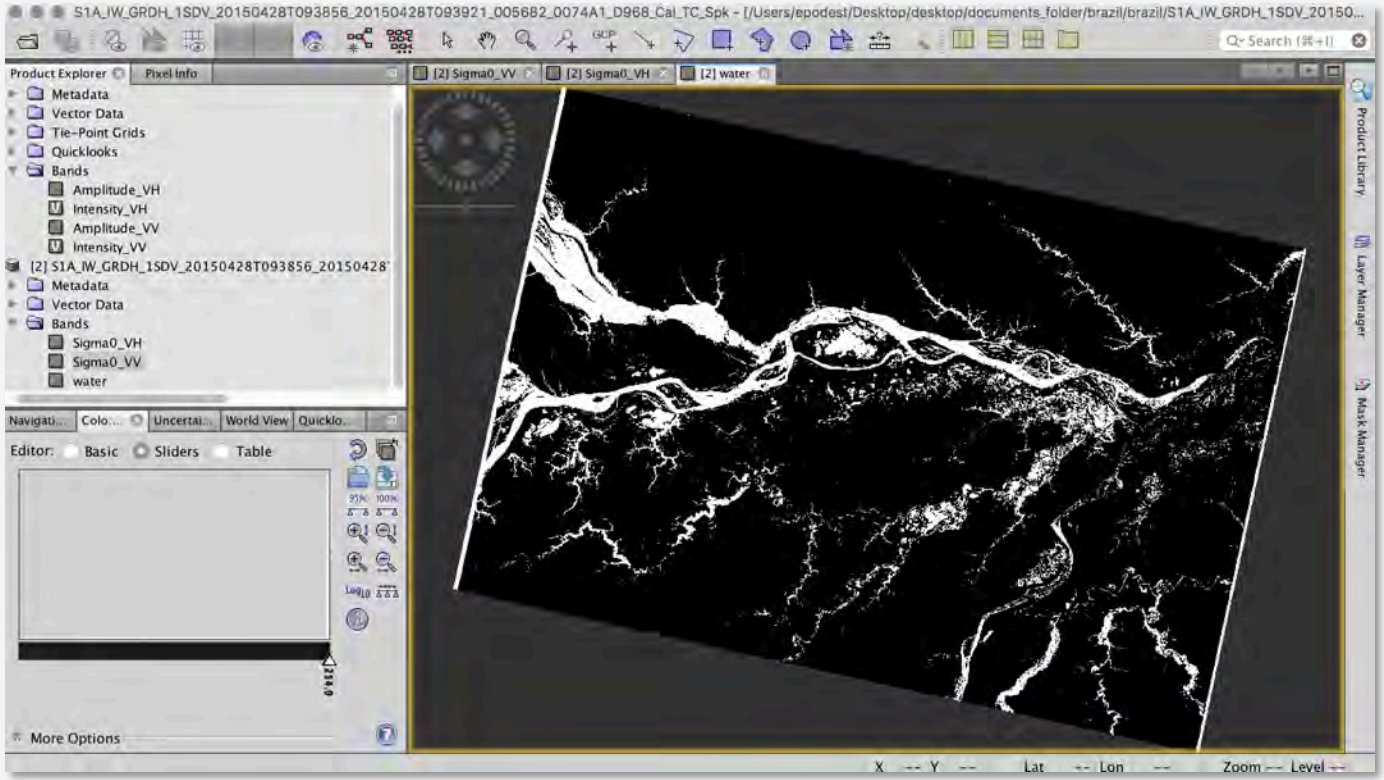

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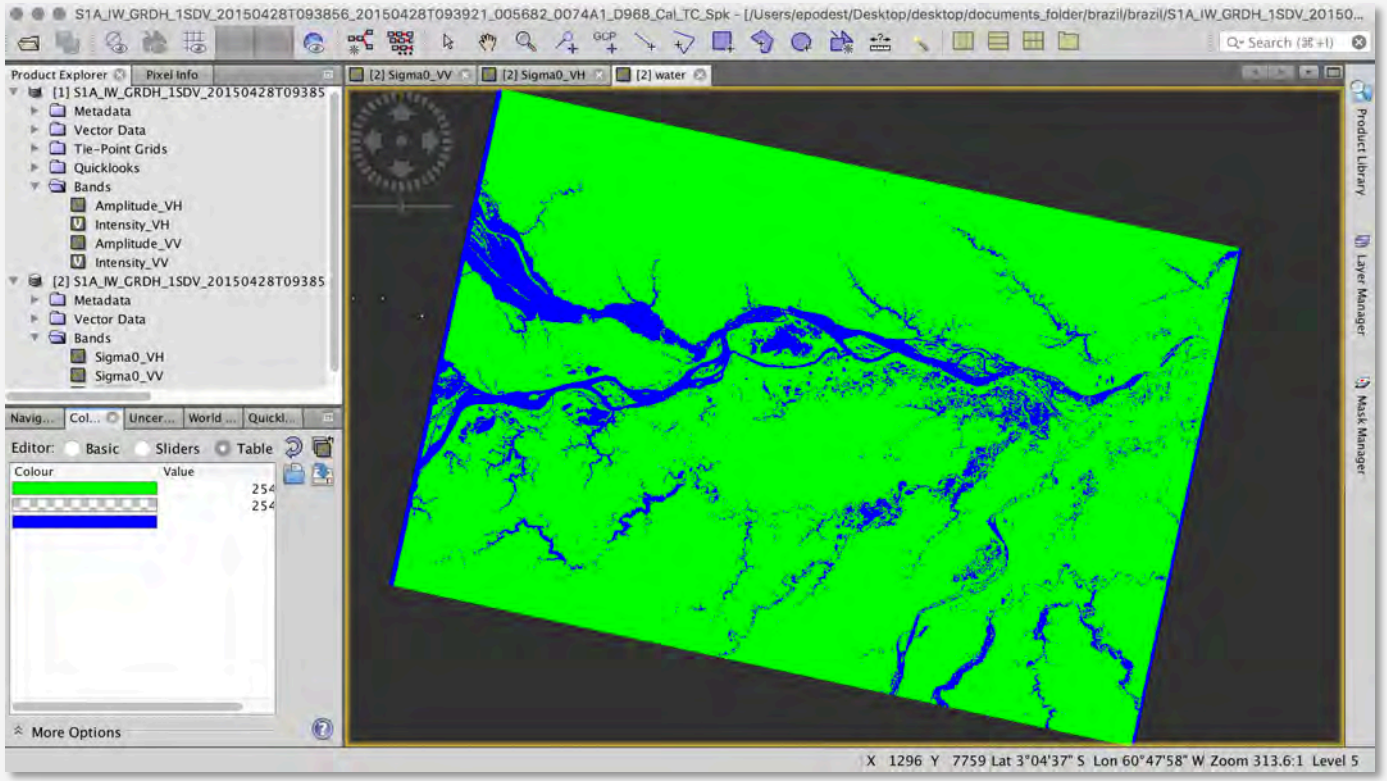

Summary

There are various stages in order to generate a product

1. Data Preparation
   – Acquire the images
   – Identify a subsection of the image or create a mosaic, if needed
2. Preprocessing of the image
   – Radiometric calibration
   – Geometric calibration
   – Filter application to reduce speckle
3. Processing of the images
   – Classify the image through an index, supervised or non-supervised approaches